

415-902

GOULDS PUMPS, INC.

SENECA FALLS, N. Y.

780-3

HYDRAULIC DATA

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DEFINITIONS

SUCTION LIFT exists when the source of supply is below the center line of the pump.

STATIC SUCTION LIFT is the vertical distance in feet from the center line of the pump to the free level of the liquid to be pumped.

TOTAL DYNAMIC SUCTION LIFT is the vertical distance in feet from the center line of the pump to the free level of the liquid to be pumped plus Velocity Head plus all friction losses in the suction pipe and fittings.

TOTAL DYNAMIC SUCTION LIFT, as determined on test, is the reading of a mercury column or vacuum gauge connected to suction nozzle of pump, plus vertical distance between point of attachment of mercury column to center of pump, plus head of water resting on mercury column, if any.

SUCTION HEAD exists when the source of supply is above the center line of the pump.

STATIC SUCTION HEAD is the vertical distance in feet from the center line of the pump to the free level of the liquid to be pumped.

TOTAL DYNAMIC SUCTION HEAD is the vertical distance in feet from the center line of the pump to the free level of the liquid to be pumped minus Velocity Head and minus all friction losses in suction pipe and fittings.

TOTAL DYNAMIC SUCTION HEAD, as determined by test, is the reading of a gauge connected to suction nozzle of pump, minus vertical distance from center of gauge to center of line pump. Suction Head, after deducting the various losses, may be a negative quantity, in which case a condition equivalent to Suction Lift will prevail.

TOTAL STATIC HEAD is the vertical distance in feet between the free level of the source of supply and the point of free discharge or to the level of the free surface of the discharge water.

Tabulating velocities and the corresponding velocity heads:

Velocity, ft. per second

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Velocity head														
0	.06	.14	.25	.39	.56	.76	1.01	1.25	1.55	1.87	2.24	2.62	3.05	3.5

Note: It is standard practice to give head in feet not in pounds per square inch when referring to centrifugal pumps. This is contrary to the practice in use for reciprocating pumps where pounds per square inch is always used.

WATER HORSEPOWER is obtained from the formula:

$$\text{Water HP} = \frac{\text{gpm} \times \text{head in feet} \times \text{specific gravity}}{3960}$$

Note: The constant 3960 is obtained by dividing the number of foot pounds for one horsepower (33,000) by the weight of one gallon of water (8.33 pounds).

$$\text{or} \quad \frac{\text{gpm} \times \text{head in pounds per square inch}}{1714}$$

TOTAL DYNAMIC HEAD is the vertical distance in feet between the free level of the source of supply and the point of free discharge or to the level of the free surface of the discharge water, plus velocity head and all friction losses.

TOTAL DYNAMIC HEAD, as determined on test, where Suction Lift exists, is the reading of a mercury column or vacuum gauge connected to the suction nozzle of the pump, plus the reading of a pressure gauge connected to discharge nozzle of pump, plus vertical distance between point of attachment of mercury column and center of gauge, plus excess, if any, of Velocity Head of discharge over Velocity Head of suction as measured at points where the instruments are attached, plus head of water resting on mercury column, if any.

TOTAL DYNAMIC HEAD, as determined on test, where Suction Head exists, is the reading of a gauge attached to the discharge nozzle of pump, minus the reading of gauge connected to the suction nozzle of pump, plus or minus vertical distance between centers of gauges (depending on whether suction gauge is below or above discharge gauge), plus excess, if any, of Velocity Head of discharge over Velocity Head of suction as measured at points where instruments are attached.

VELOCITY HEAD, sometimes called the head due to velocity, is the equivalent head in feet through which the water would have to fall to acquire the same velocity, or in other words, the head necessary to accelerate the water. (Table of Velocity Heads will be found on page 5.)

VELOCITY HEAD FORMULA:

$$h = \frac{V^2}{2g}$$

Where V = velocity of the water through the pipe in feet per second.

Where h = head in feet (velocity head).

Where g = 32.2 feet per second, acceleration due to gravity.

BRAKE HORSEPOWER is obtained from the formula:

$$\text{Brake hp} = \frac{\text{water hp}}{\text{efficiency of pump}}$$

KW-hours per 1000 gallons of cold water pumped per hour is obtained from the formula:

$$\text{KW hrs.} = \frac{\text{head in feet} \times 0.00315}{\text{efficiency of pump} \times \text{efficiency of motor}}$$

Friction of Water in Pipes

The Tables on the following pages may be used for all liquids having a viscosity equal to that of water. The head loss and the velocity head will read in feet of the liquid, regardless of the specific gravity. Tables are based on the Williams and Hazen Formula.

Rate of Flow in Gals. per Min.	NOMINAL DIAMETER OF PIPE												Rate of Flow in Gals. per Min.	
	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"	5"			
Loss of Head in Feet Due to Friction, per 100 feet of 15 yr. old, Ordinary Iron Pipe														
1	121	28	6.4	2.1									1	
2		103	23.3	7.4	1.9								2	
3			49.0	15.8	4.1	1.26							3	
4			84.0	27.0	7.0	2.14	0.57	0.26					4	
5			126.0	41.0	10.5	3.25	0.84	0.40					5	
10				147.0	38.0	11.7	3.05	1.43	0.50	0.17	0.07		10	
15					80.0	25.0	6.50	3.0	1.08	0.36	0.15		15	
20					136.0	42.0	11.10	5.2	1.82	0.61	0.25		20	
25						64.0	16.6	7.8	2.73	0.92	0.38		25	
30						89.0	23.5	11.0	3.84	1.29	0.54		30	
35						119.0	31.2	14.7	5.1	1.72	0.75		35	
40						152.0	40.0	18.8	6.6	2.20	0.91	0.22	40	
45							50.0	23.2	8.2	2.80	1.15	0.28	45	
50							60.0	28.4	9.9	3.32	1.38	0.34	50	
70							113.0	53.0	18.4	6.20	2.57	0.63	70	
75								60.0	20.9	7.1	3.00	0.73	75	
100								102	35.8	12.0	4.96	1.22	100	
125								143	50.0	16.8	7.0	1.71	125	
150									54.0	18.2	7.6	1.86	150	
									76.0	25.5	10.5	2.62	175	
175									102	33.8	14.0	3.44	175	
200									129	43.1	17.8	4.40	200	
225										54.3	22.3	5.45	225	
250										66.0	27.2	6.72	250	
270											31.3	7.70	2.60	270
275											32.5	8.05	2.70	275
300											38.0	9.30	3.14	300
350												12.40	4.19	350
400												16.00	5.40	400
450												19.80	6.70	450
470												21.60	7.22	470
475												22.00	7.42	475
500												24.00	8.10	500
550													9.60	550
600													11.30	600
650													13.20	650
700													15.10	700
750													17.20	750

Pipe Coefficients

The values of friction given in this table are for commercial wrought iron or cast iron pipe of 15 years' service when handling soft clear water. In order to be able to use that table for other classes of pipe, the values taken from the table should be multiplied by a coefficient, selected from the list below, to correspond to the required condition.

New smooth brass and steel pipe (Durand) coefficient.....=0.6

New smooth iron pipe (Williams & Hazen C=120).....=0.7

15-yr.-old ordinary pipe (Williams & Hazen C=100).....=1.0

25-yr.-old ordinary pipe (Williams & Hazen C=90).....=1.2

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 15-yr.-old ordinary pipe (Williams & Hazen C=100).....=1.0
 25-yr.-old ordinary pipe (Williams & Hazen C=90).....=1.2

Friction of Water in 90° Elbows

Equivalent Number of Feet Straight Pipe

Size of Elbow, Inches	1/8"	1/4"	3/8"	1/2"	5/8"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"	5"
Friction Equivalent Feet Straight Pipe				1.5	2.2	2.8	3.7	4.5	5.5	6.5	8.1	12	14

Approximate Rules for Interpolating when Exact Rating is not shown in Table.

Rule 1. At a constant head capacity is proportional to $d^{2.5}$.

Example: A 4 inch pipe discharges 100 GPM. How much would a 2 inch pipe discharge under the same conditions?

$$100 \times \frac{5.66}{32} = 17.6 \text{ GPM.}$$

*When estimating, it is well to remember that $d^{2.5} = d \times d \times \sqrt{d}$.

Rule 2. At constant capacity, head is inversely proportional to the fifth power of the diameter.

Example: What is the friction of 500 G. P. M. in a 3-inch pipe?

The nearest figure in table shows 24.00 feet for 4-inch pipe, and the friction in a 3-inch pipe must be greater,

hence
$$h = \frac{24.00 \times 4^5}{3^5} = 101 \text{ feet.}$$

Rule 3. At constant diameter, head is proportional to capacity squared.

Example: 100 GPM produces 5 ft. friction in a pipe, how much will 200 GPM produce?

Answer:
$$5 \times \frac{200^2}{100^2} = 20 \text{ ft.}$$

Friction of Water in Pipes

Rate of Flow in Gals. per Min.	NOMINAL DIAMETER OF PIPE											Rate of Flow in Gals. per Min.	
	6"	8"	10"	12"	14"	15"	16"	20"	24"	30"	36"		42"
Loss of Head in Feet Due to Friction, per 100 Feet of 15 yr. old, Ordinary Iron Pipe													
100	0.17											100	
120	0.24											120	
125	0.27											125	
150	0.36											150	
175	0.48											175	
200	0.62											200	
225	0.77											225	
250	0.95	0.23										250	
270	1.08	0.26										270	
275	1.12	0.27										275	
300	1.32	0.32										300	
350	1.75	0.42										350	
400	2.21	0.55										400	
450	2.37	0.69	0.23									450	
470	2.99	0.74	0.25									470	
475	3.02	0.76	0.25									475	
500	3.34	0.83	0.28	0.11								500	
550	4.02	0.98	0.33	0.14								550	
600	4.91	1.16	0.40	0.16								600	
650	5.40	1.34	0.45	0.19	0.09							650	
700	6.20	1.54	0.52	0.21	0.10							700	
750	7.12	1.77	0.60	0.25	0.11							750	
800	8.00	1.90	0.67	0.27	0.13							800	
850	8.95	2.20	0.75	0.31	0.14							850	
900	10.11	2.46	0.83	0.34	0.16							900	
950	11.20	2.71	0.92	0.38	0.18	0.12						950	
1000	12.04	2.98	1.01	0.41	0.20	0.14						1000	
1050	13.25	3.22	1.09	0.45	0.21	0.15						1050	
1100	14.55	3.55	1.21	0.49	0.23	0.16						1100	
1150	15.60	3.83	1.31	0.54	0.25	0.18						1150	
1200	17.10	4.17	1.42	0.58	0.27	0.19						1200	
1250	18.50	4.43	1.51	0.62	0.29	0.20	0.15					1250	
1500		6.29	2.14	0.89	0.42	0.29	0.22					1500	
2000		10.80	3.60	1.49	0.70	0.49	0.37					2000	
2500			5.40	2.26	1.07	0.74	0.50					2500	
3000			7.72	3.15	1.49	1.03	0.80	0.27				3000	
3500			10.00	4.16	1.96	1.37	1.04	0.35	0.14			3500	
4000				5.41	2.55	1.75	1.34	0.45	0.18			4000	
4200				5.90	2.60	1.94	1.45	0.49	0.20			4200	
4500				6.77	3.20	2.22	1.67	0.58	0.23	0.08		4500	
5000				8.17	3.86	2.68	2.02	0.68	0.28	0.09		5000	
5500					4.72	3.35	2.42	0.82	0.33	0.11		5500	
6000					5.51	3.89	2.81	0.95	0.39	0.13	0.05	6000	
6500					6.39	4.53	3.27	1.10	0.45	0.15	0.06	6500	
7000					7.30		5.18	1.26	0.52	0.18	0.07	7000	
7200							5.47	1.33	0.55	0.18	0.08	7200	
7500							5.93	1.45	0.59	0.20	0.08	7500	
8000								1.63	0.67	0.23	0.09	8000	
8500								1.81	0.73	0.25	0.10	8500	
9000								2.03	0.83	0.28	0.12	9000	
9500								2.22	0.92	0.31	0.13	9500	
10000								2.45	1.01	0.34	0.14	0.07	10000
10500									1.10	0.37	0.15	0.07	10500
11000									1.20	0.41	0.17	0.08	11000
11500									1.31	0.44	0.18	0.09	11500
12000									1.40	0.47	0.19	0.09	12000
12500									1.52	0.51	0.21	0.10	12500
13000									1.64	0.55	0.23	0.11	13000
13500									1.75	0.59	0.24	0.12	13500

Pipe Coefficients

The values of friction given in this table are for commercial wrought iron or cast iron pipe of 15 years' service when handling soft clear water. In order to be able to use that table for other classes of pipe, the values taken from the table should be multiplied by a coefficient, selected from the list below, to correspond to the required condition.

New smooth brass and steel pipe (Durand), coefficient.....=0.6
 New smooth iron pipe (Williams & Hazen C=120).....=0.7
 15-yr.-old ordinary pipe (Williams & Hazen C=100).....=1.0
 25-yr.-old ordinary pipe (Williams & Hazen C=90).....=1.2

Friction of Water in 90° Elbows

Equivalent Number of Feet Straight Pipe

Size of Elbow, Inches	6"	8"	10"	12"	14"	15"	16"	20"	24"	30"	36"	42"
Friction Equivalent Feet Straight Pipe	16	21	26	32	37	40	42	52	64	80	95	120

EXAMPLE OF USE OF FRICTION TABLES AND FITTINGS CHART - Page 6

What is Loss due to Friction, in Lbs. per Sq. Inch, when pumping 20 gallons per minute through 200 feet of 2-inch pipe with 6-90° and 2-45° elbows?

Total Equivalent Length of Pipe = 200 + (5.5 × 6 Elbows) + (2.6 × 2 Elbows) = 238 Feet of Pipe or 2.38 Hundred Feet of Pipe.

Friction Loss in Feet Head = 2.38 × 1.82 = 4.33 Feet Head Loss = 4.33 × .434 = 1.88 Lbs. Pressure Loss in Head.

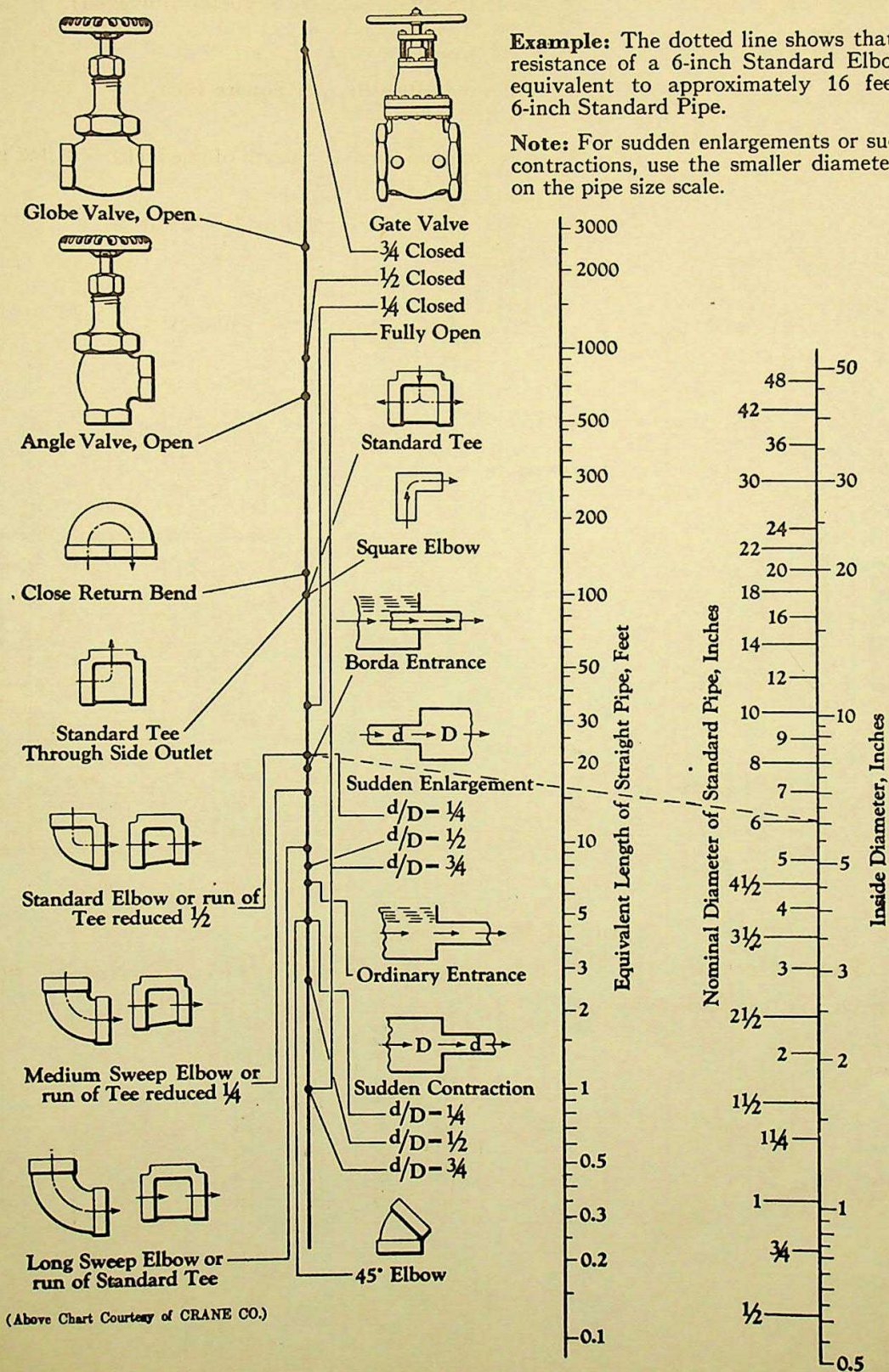
Velocity in Pipes

Rate of Flow in Gals. per Min.	NOMINAL DIAMETER OF PIPE														Rate of Flow in Gals. per Min.
	8"	10"	12"	14"	16"	18"	20"	24"	30"	36"	42"	48"	60"		
	(Velocity in Feet Per Second)														
1	5.60	3.08	1.67	1.05										1	
2		6.16	3.35	2.10	1.20									2	
3			5.02	3.16	1.80	1.12								3	
4			6.70	4.21	2.41	1.49	0.86	0.63						4	
5			8.37	5.26	3.01	1.86	1.07	0.79						5	
10				10.52	6.02	3.72	2.14	1.57	1.02	0.65	0.45			10	
15					9.02	5.60	3.21	2.36	1.53	0.98	0.68			15	
20					12.03	7.44	4.29	3.15	2.04	1.31	0.91			20	
25						9.30	5.36	3.94	2.55	1.63	1.13			25	
30						11.15	6.43	4.72	3.06	1.96	1.36			30	
35						13.02	7.51	5.51	3.57	2.29	1.58			35	
40						14.88	8.58	6.30	4.08	2.61	1.82			40	
45							9.65	7.08	4.60	2.94	2.04	1.15		45	
50							10.72	7.87	5.11	3.27	2.27	1.28		50	
70							15.01	11.02	7.15	4.58	3.18	1.79	1.14	70	
75								11.80	7.66	4.90	3.40	1.92	1.22	75	
100								15.74	10.21	6.54	4.54	2.55	1.63	1.10	100
120								18.89	12.25	7.84	5.45	3.06	1.96	1.36	120
125									12.75	8.16	5.66	3.19	2.04	1.42	125
150									15.32	9.80	6.80	3.84	2.45	1.70	150
175									17.85	11.40	7.94	4.46	2.86	1.98	175
200	8"								20.42	13.07	9.08	5.11	3.27	2.27	200
225										14.70	10.20	5.75	3.67	2.55	225
250	1.60									16.30	11.32	6.38	4.08	2.84	250
270	1.73										12.25	6.90	4.41	3.06	270
275	1.76										12.50	7.03	4.49	3.12	275
300	1.92										13.62	7.66	4.90	3.40	300
350	2.24	10"										8.94	5.72	3.98	350
400	2.56											10.21	6.54	4.54	400
450	2.88	1.84										11.49	7.35	5.11	450
470	3.01	1.92	12"									12.00	7.68	5.34	470
475	3.04	1.94										12.10	7.75	5.40	475
500	3.20	2.04	1.42									12.77	8.17	5.68	500
550	3.52	2.25	1.56										8.99	6.24	550
600	3.84	2.45	1.70	14"									9.80	6.81	600
650	4.16	2.65	1.85	1.30									10.62	7.38	650
700	4.48	2.86	1.99	1.40									11.44	7.94	700
750	4.80	3.06	2.13	1.50									12.26	8.50	750
800	5.12	3.27	2.27	1.60										9.08	800
850	5.45	3.47	2.41	1.70										9.65	850
900	5.76	3.67	2.56	1.80	15"									10.20	900
950	6.08	3.88	2.70	1.90	1.67									10.77	950
1000	6.40	4.08	2.84	2.00	1.76									11.34	1000
1050	6.72	4.29	2.98	2.10	1.85									11.90	1050
1100	7.04	4.49	3.13	2.20	1.93									12.48	1100
1150	7.36	4.70	3.27	2.30	2.02	16"								13.05	1150
1200	7.68	4.90	3.41	2.40	2.11									13.61	1200
1250	8.00	5.41	3.55	2.50	2.20	1.99								14.20	1250
1500	9.60	6.12	4.26	3.05	2.64	2.09									1500
2000	12.80	8.10	5.68	4.00	3.52	3.09	20"								2000
2500		10.20	7.10	5.01	4.40	3.98		24"							2500
3000		12.24	8.52	6.01	5.28	4.78	3.07		30"						3000
3500		14.50	9.95	7.02	6.16	5.58	3.53	2.43							3500
4000			11.36	8.02	7.04	6.33	4.10	2.83	1.81						4000
4200			11.92	8.42	7.40	6.70	4.30	2.97	1.90						4200
4500			12.78	9.02	7.92	7.17	4.61	3.19	2.04						4500
5000			14.20	10.02	8.80	7.96	5.12	3.54	2.26	36"					5000
5500				11.01	9.69	8.77	5.63	3.90	2.49						5500
6000				12.00	10.56	9.56	6.14	4.25	2.72	1.57					6000
6500				13.00	11.44	10.36	6.66	4.60	2.94	2.05					6500
7000				14.02			7.16	4.97	3.17	2.21					7000
7200							7.38	5.16	3.26	2.27					7200
7500							7.68	5.32	3.40	2.37					7500
8000							8.20	5.66	3.62	2.52					8000
8500							8.70	6.02	3.85	2.68					8500
9000							9.21	6.38	4.08	2.84	42"				9000
9500							9.72	6.72	4.31	3.00					9500
10000							10.24	7.08	4.58	3.15	2.31				10000
10500								7.44	4.76	3.30	2.43				10500
11000								7.79	4.99	3.46	2.55				11000
11500								8.15	5.22	3.62	2.66				11500
12000								8.50	5.44	3.78	2.78				12000
12500								8.85	5.67	3.93	2.89				12500
13000								9.20	5.90	4.00	3.01				13000
13500								9.56	6.12	4.25	3.13				13500

Velocity Head in Pipes

Rate of Flow in Gals. per Min.	NOMINAL DIAMETER OF PIPE														Rate of Flow in Gals. per Min.
	¾"	1"	1¼"	1½"	2"	2½"	3"	4"	5"	6"					
	(Velocity Heads in Feet)														
1	.488	.148	.043	.017											1
2		.590	.175	.069	.022										2
3			.392	.155	.050	.020									3
4			.698	.276	.090	.035	.012	.006							4
5			1.089	.430	.141	.054	.018	.010							5
10				1.720	.564	.215	.071	.038	.016	.007	.003				10
15					1.265	.488	.160	.087	.036	.015	.007				15
20					2.250	.861	.286	.154	.065	.027	.013				20
25						1.345	.447	.241	.101	.041	.020				25
30						1.933	.643	.346	.146	.060	.029				30
35						2.635	.877	.472	.198	.082	.039				35
40						3.343	1.145	.618	.259	.106	.052	.016			40
45							1.548	.779	.329	.134	.065	.021			45
50							1.787	.963	.406	.166	.080	.026			50
70							3.503	1.888	.795	.326	.157	.050	.020		70
75								2.165	.912	.373	.180	.057	.023		75
100								3.851	1.621	.665	.320	.101	.041	.020	100
120								5.548	2.333	.956	.462	.146	.060	.029	120
125									2.528	1.035	.498	.158	.065	.031	125
150									3.649	1.493	.736	.229	.093	.045	150
175									4.954	2.021	.980	.309	.127	.061	175
200	8"								6.483	2.656	1.281	.406	.166	.080	200
225										3.359	1.618	.514	.209	.101	225
250	.040									4.131	1.992	.633	.259	.125	250
270	.047										2.333	.740	.302	.146	270
275	.048										2.429	.769	.313	.151	275
300	.057										2.883	.912	.373	.180	300
350	.078	10"										1.242	.509	.246	350
400	.102											1.621	.665	.320	400
450	.129	.053										2.053	.839	.406	450
470	.141	.057	12"									2.239	.917	.443	470
475	.144	.059										2.276	.934	.453	475
500	.159	.065	.031									2.535	1.038	.502	500
550	.193	.079	.038	14"									1.256	.606	550
600	.229	.093	.045										1.493	.721	600
650	.269	.109	.053	.026									1.752	.846	650
700	.312	.127	.062	.031									2.035	.980	700
750	.358	.146	.071	.035									2.337	1.123	750
800	.407	.166	.080	.040										1.281	800
850	.462	.187	.090	.045										1.548	850
900	.516	.209	.102	.050	15"									1.618	900
950	.574	.234	.113	.056	.043									1.813	950
1000	.637	.259	.125	.062	.048									1.999	1000
1050	.703	.296	.138	.069	.053									2.202	1050
1100	.771	.313	.152	.075	.058									2.421	1100
1150	.841	.343	.166	.082	.064	16"								2.648	1150
1200	.917	.373	.181	.090	.069									2.880	1200
1250	.995	.406	.196	.097	.075	.062								3.135	1250
1500	1.433	.582	.282	.145	.108	.088									1500
2000	2.547	1.035	.502	.249	.193	.158									2000
2500	1.618	.784	.391	.301	.246		20"								2500
3000	2.329	1.128	.562	.434	.355	.147		24"							3000
3500	3.224	1.540	.766	.590	.502	.199			30"						3500
4000		2.007	.771	.633	.261	.125				.051					4000
4200		2.209	1.102	.851	.698	.288				.056					4200
4500		2.539	1.265	.975	.799	.330				.065					4500
5000		3.135	1.561	1.204	.985	.407				.079					5000
5500			1.884	1.460	1.196	.493				.096					5500
6000			2.239	1.733	1.421	.586				.115	.056				6000
6500			2.627	2.035	1.669	.690				.134	.065				6500
7000			3.056	2.360	1.936	.797				.156	.076				7000
7200				2.709	2.056	.846				.165	.080				7200
7500				3.047	2.224	.917				.180	.087				7500
8000						1.045				.204	.099				8000
8500						1.177				.230	.112				8500
9000						1.319				.259	.125				9000
9500						1.469				.289	.140				9500
10000						1.630				.319	.154	.083			10000
10500										.352	.169	.092			10500
11000										.387	.186	.101			11000
11500										1.033	.423	.204	.110		11500
12000										1.123	.460	.222	.120		12000
12500										1.218	.500	.240	.130		12500
13000										1.316	.541	.260	.141		13000
13500										1.421	.582	.281	.152		13500

Resistance of Valves and Fittings to Flow of Fluids



(Above Chart Courtesy of CRANE CO.)

MISCELLANEOUS DATA

General Information:

Specific Gravity of water at 60° F. = 1.0

Viscosity of water at 60° F. = 31.5 S.S.U. (Seconds Sayboldt Universal).

Conversion Factors:

Feet Head x .434 x Specific Gravity = Pounds Pressure per Square Inch.

Pounds Pressure x 2.31 ÷ Specific Gravity = Feet Head.

Meters x 3.28 = Feet Head.

1 acre-inch (quantity of water required to cover one acre to a depth of one inch) = 27,152 gallons.

1 acre-inch in 12 hours pumping = 37.7 gallons per minute.

Inches of Mercury x 1.133 = feet head of water.

Capacity of a barrel varies in different industries. More common barrels are:

1 bbl. Beer = 31 U. S. gallons

1 bbl. Whiskey = 45 U. S. gallons

1 bbl. Oil = 42 U. S. gallons

Barrels per day x 0.02917 = gallons per minute (if barrel has 42 gallons).

Velocity of Flow Formula:

$$\text{Velocity of flow in a pipe in feet per second} = \frac{\text{G.P.M.} \times .408}{(\text{diameter in inches})^2}$$

Weight and Volume Equivalents:

	U. S. Gallon	Imperial Gallon	Cubic Inch	Cubic Foot	Pound	Cwt. (U. S.)	Ton	Liter	Cubic Meter
U. S. Gallon.....	1.	.8327	231.	.13368	8.345	.08345	.00418	3.785	.00378
Imperial Gallon	1.201	1.	277.41	.1605	10.02	.1002	.00502	4.546	.00455
Cubic Inch	.004329	.003607	1.	.000579	.036124				.0164
Cubic Foot	7.4805	6.232	1728.	1.	62.425	.6243	.03121	28.317	.0283
Pound*	.1198	.0998	27.68	.01602	1.	.01	.0005	.454	
Cwt. (U. S.)*	11.98	9.98	2768.	1.602	100.	1.	.05	45.36	.0454
Ton*	239.6	199.6		32.04	2000.	20.0	1.	906.9	.907
Liter	.2642	.22	61.023	.0353	2.205	.022	.0011	1.	.001
Cubic Meter	264.2	220.		35.314	2204.5	22.045	1.102	1000.	1.

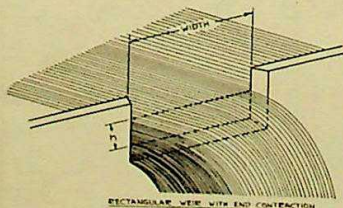
* Volume — weight relationships taken for water at greatest density (39.2° F.).

Table of Weir Discharges

A. Weir—Rectangular

$$Q = 1495 h \sqrt{h} \text{ per Foot of Width}$$

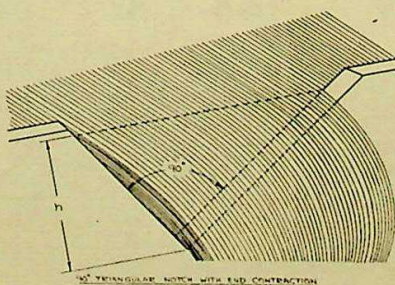
Q = Gal. per Min. h = Feet



B. Weir—Triangular Notch—90°

$$Q = 449 \left(2.42 + \frac{.067}{\sqrt{h}} \right) h^2 \sqrt{h}$$

Q = Gal. per Min. h = Feet



Head on Weir (feet).....	.2	.3	.4	.5	.6	.7	.8	.9	1.0	1.1	1.2	1.3	1.4	1.5
Discharge GPM (rectangular)....	134	200	380	530	680	875	1070	1275	1495	1730	1975	2150	2480	2750
Discharge GPM (triangular).....	21	38	114	200	316	458	640	860	1110	1420	1760	2000	2580	3160

Theoretical Discharge of Nozzles in U. S. Gallons per Minute

Head		Veloc'y of Disch. Feet per Sec.	Diameter of Nozzle in Inches											
Lbs.	Feet		1/8	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 1/2	1 3/4
10	23.1	38.6	0.37	1.48	3.32	5.91	13.3	23.6	36.9	53.1	72.4	94.5	120	148
15	34.6	47.25	0.45	1.81	4.06	7.24	16.3	28.9	45.2	65.0	88.5	116.	147	181
20	46.2	54.55	0.52	2.09	4.69	8.35	18.8	33.4	52.2	75.1	102.	134.	169	209
25	57.7	61.0	0.58	2.34	5.25	9.34	21.0	37.3	58.3	84.0	114.	149.	189	234
30	69.3	66.85	0.64	2.56	5.75	10.2	23.0	40.9	63.9	92.0	125.	164.	207	256
35	80.8	72.2	0.69	2.77	6.21	11.1	24.8	44.2	69.0	99.5	135.	177.	224	277
40	92.4	77.2	0.74	2.96	6.64	11.8	26.6	47.3	73.8	108.	145.	189.	239	296
45	103.9	81.8	0.78	3.13	7.03	12.5	28.2	50.1	78.2	113.	153.	200.	253	313
50	115.5	86.25	0.83	3.30	7.41	13.2	29.7	52.8	82.5	119.	162.	211.	267	330
55	127.0	90.4	0.87	3.46	7.77	13.8	31.1	55.3	86.4	125.	169.	221.	280	346
60	138.6	94.5	0.90	3.62	8.12	14.5	32.5	57.8	90.4	130.	177.	231.	293	362
65	150.1	98.3	0.94	3.77	8.45	15.1	33.8	60.2	94.0	136.	184.	241.	305	376
70	161.7	102.1	0.98	3.91	8.78	15.7	35.2	62.5	97.7	141.	191.	250.	317	391
75	173.2	105.7	1.01	4.05	9.08	16.2	36.4	64.7	101.	146.	198.	259.	327	404
80	184.8	109.1	1.05	4.18	9.39	16.7	37.6	66.8	104.	150.	205.	267.	338	418
85	196.3	112.5	1.08	4.31	9.67	17.3	38.8	68.9	108.	155.	211.	276.	349	431
90	207.9	115.8	1.11	4.43	9.95	17.7	39.9	70.8	111.	160.	217.	284.	359	443
95	219.4	119.0	1.14	4.56	10.2	18.2	41.0	72.8	114.	164.	223.	292.	369	456
100	230.9	122.0	1.17	4.67	10.5	18.7	42.1	74.7	117.	168.	229.	299.	378	467
105	242.4	125.0	1.20	4.79	10.8	19.2	43.1	76.5	120.	172.	234.	306.	388	479
110	254.0	128.0	1.23	4.90	11.0	19.6	44.1	78.4	122.	176.	240.	314.	397	490
115	265.5	130.9	1.25	5.01	11.2	20.0	45.1	80.1	125.	180.	245.	320.	406	501
120	277.1	133.7	1.28	5.12	11.5	20.5	46.0	81.8	128.	184.	251.	327.	414	512
125	288.6	136.4	1.31	5.22	11.7	20.9	47.0	83.5	130.	188.	256.	334.	423	522
130	300.2	139.1	1.33	5.33	12.0	21.3	48.0	85.2	133.	192.	261.	341.	432	533
135	311.7	141.8	1.36	5.43	12.2	21.7	48.9	86.7	136.	195.	266.	347.	439	543
140	323.3	144.3	1.38	5.53	12.4	22.1	49.8	88.4	138.	199.	271.	354.	448	553
145	334.8	146.9	1.41	5.62	12.6	22.5	50.6	89.9	140.	202.	275.	360.	455	562
150	346.4	149.5	1.43	5.72	12.9	22.9	51.5	91.5	143.	206.	280.	366.	463	572
175	404.1	161.4	1.55	6.18	13.9	24.7	55.6	98.8	154.	222.	302.	395.	500	618
200	461.9	172.6	1.65	6.61	14.8	26.4	59.5	106.	165.	238.	323.	423.	535	647
250	577.4	193.0	1.85	7.39	16.6	29.6	66.5	118.	185.	266.	362.	473.	598	739
300	692.8	211.2	2.02	8.08	18.2	32.4	72.6	129.	202.	291.	396.	517.	655	808

Head		Veloc'y of Disch. Feet per Sec.	Diameter of Nozzle in Inches												
Lbs.	Feet		1½	1¾	2	2¼	2½	2¾	3	3¼	4	4½	5	5½	6
10	23.1	38.6	213	289	378	479	591	714	851	1158	1510	1915	2365	2855	3405
15	34.6	47.25	260	354	463	585	723	874	1041	1418	1850	2345	2890	3490	4165
20	46.2	54.55	301	409	535	676	835	1009	1203	1638	2135	2710	3340	4040	4810
25	57.7	61.0	336	458	598	756	934	1128	1345	1830	2385	3025	3730	4510	5380
30	69.3	66.85	368	501	655	828	1023	1236	1473	2005	2615	3315	4090	4940	5895
35	80.8	72.2	398	541	708	895	1106	1335	1591	2168	2825	3580	4415	5340	6370
40	92.4	77.2	425	578	756	957	1182	1428	1701	2315	3020	3830	4725	5710	6810
45	103.9	81.8	451	613	801	1015	1252	1512	1802	2455	3200	4055	5000	6050	7210
50	115.5	86.25	475	647	845	1070	1320	1595	1900	2590	3375	4275	5280	6380	7600
55	127.0	90.4	498	678	886	1121	1385	1671	1991	2710	3540	4480	5530	6690	7970
60	138.6	94.5	521	708	926	1172	1447	1748	2085	2835	3700	4685	5790	6980	8330
65	150.1	98.3	542	737	964	1220	1506	1819	2165	2950	3850	4875	6020	7270	8670
70	161.7	102.1	563	765	1001	1267	1565	1888	2250	3065	4000	5060	6250	7560	9000
75	173.2	105.7	582	792	1037	1310	1619	1955	2330	3170	4135	5240	6475	7820	9320
80	184.8	109.1	602	818	1070	1354	1672	2020	2405	3280	4270	5410	6690	8080	9630
85	196.3	112.5	620	844	1103	1395	1723	2080	2480	3375	4400	5575	6890	8320	9920
90	207.9	115.8	638	868	1136	1436	1773	2140	2550	3475	4530	5740	7090	8560	10210
95	219.4	119.0	656	892	1168	1476	1824	2200	2625	3570	4655	5900	7290	8800	10500
100	230.9	122.0	672	915	1196	1512	1870	2255	2690	3660	4775	6050	7470	9030	10770
105	242.4	125.0	689	937	1226	1550	1916	2312	2755	3750	4890	6200	7650	9250	11020
110	254.0	128.0	705	960	1255	1588	1961	2366	2820	3840	5010	6350	7840	9470	11300
115	265.5	130.9	720	980	1282	1621	2005	2420	2885	3930	5120	6490	8010	9680	11550
120	277.1	133.7	736	1002	1310	1659	2050	2470	2945	4015	5225	6630	8180	9900	11800
125	288.6	136.4	751	1022	1338	1690	2090	2520	3005	4090	5340	6760	8350	10100	12030
130	300.2	139.1	767	1043	1365	1726	2132	2575	3070	4175	5450	6900	8530	10300	12290
135	311.7	141.8	780	1063	1390	1759	2173	2620	3125	4250	5550	7030	8680	10490	12510
140	323.3	144.3	795	1082	1415	1790	2212	2670	3180	4330	5650	7160	8850	10690	12730
145	334.8	146.9	809	1100	1440	1820	2250	2715	3235	4410	5740	7280	8990	10880	12960
150	346.4	149.5	824	1120	1466	1853	2290	2760	3295	4485	5850	7410	9150	11070	13200
175	404.1	161.4	890	1210	1582	2000	2473	2985	3560	4840	6310	8000	9890	11940	14250
200	461.9	172.6	950	1294	1691	2140	2645	3190	3800	5175	6750	8550	10580	12770	15220
250	577.4	193.0	1063	1447	1891	2392	2955	3570	4250	5795	7550	9570	11820	14290	17020
300	692.8	211.2	1163	1582	2070	2615	3235	3900	4650	6330	8260	10480	12940	15620	18610

Note:—The actual quantities will vary from these figures, the amount of variation depending upon the shape of nozzle and size of pipe at the point where the pressure is determined. With smooth taper nozzles the actual discharge is about 94% of the figures given in the tables.

Table of Effective Fire Streams

JOHN R. FREEMAN, C. E.

Using 100 feet of 2 1/2 inch ordinary best quality rubber-lined hose between nozzle and hydrant, or Pump

Smooth Nozzle, Size.....	1/2-Inch							1-Inch							1-Inch						
Pressure at Hydrant, lbs.....	32	43	54	65	75	86		34	46	57	69	80	91		37	50	62	75	87	100	
Pressure at Nozzle, lbs.....	30	40	50	60	70	80		30	40	50	60	70	80		30	40	50	60	70	80	
• Vertical Height, feet of Effective Stream.....	48	60	67	72	76	79		40	62	71	77	81	85		51	64	73	79	85	89	
• Horizontal Distance, feet, Effective Stream.....	37	44	50	54	58	62		42	49	55	61	66	70		47	55	61	67	72	76	
Gallons Discharged per Minute.....	90	104	116	127	137	147		123	142	159	174	188	201		161	186	208	228	246	263	

Smooth Nozzle Size.....	1 1/2-Inch							1 1/2-Inch							1 1/2-Inch						
Pressure at Hydrant, lbs.....	42	56	70	84	98	112		49	65	81	97	113	129		58	77	96	116	130	154	
Pressure at Nozzle, lbs.....	30	40	50	60	70	80		30	40	50	60	70	80		30	40	50	60	70	80	
• Vertical Height, feet of Effective Stream.....	52	65	75	83	88	92		53	67	77	85	91	95		55	69	79	87	92	97	
• Horizontal Distance, feet, Effective Stream.....	50	59	66	72	77	81		54	63	70	76	81	85		56	66	73	79	84	88	
Gallons Discharged per Minute.....	206	238	266	291	314	336		256	296	331	363	392	419		315	363	406	445	480	514	

Two hundred and fifty gallons per minute is a good standard fire stream with 80 pounds